

Studies on a Fusarium Disease of Corn and Sorghum

(Preliminary)

BY L. H. PAMMEL, C. M. KING
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BOTANY SECTION



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STUDIES ON A FUSARIUM DISEASE OF CORN AND SORGHUM (Preliminary)

By L. H. Pammel, C. M. King and J. L. Seal.

A new fusarium disease of corn made its appearance in Iowa during the season of 1914, seriously injuring the corn crop of the state and causing a loss estimated at more than \$15,000,000. It was not confined to Iowa, for reports of a similar disease were sent to the Iowa Agricultural Experiment station by H. B. Clark of Blair, Neb., who found an abundance of it there and elsewhere in that state. One of the authors observed the fusarium that same season in western Illinois and northern Missouri and Dr. E. C. Stakman reported that it occurred in Minnesota. In the following year, 1915, the disease was again abundant, tho not as severe as in 1914.

There is reason to believe that this fusarium disease is likely to furnish one of the most important problems in connection with the growing of corn some seasons. Therefore, it seems desirable to present at once, some of the preliminary results of the study of the disease, which is to be continued.

LITERATURE OF CORN ROTS.

Ear rots of corn have been described by Burrill and Barrett¹ of the Illinois Agricultural Experiment station. These rots were ascribed to several species of *Fusarium* which they designated as *Fusarium I*, *II*, *II* and *Diplodia Zeae*. The *Fusarium* species are found on the kernels and in some cases on the ears and the husks of corn; they vary in their manner of attack on the host plants.

Fusarium I forms a felty mass of white mycelium over the kernels of the ear, the threads penetrating the diseased grains. It is also found within the pith, near the node.

Fusarium II covers the ear with a pink mold, giving the diseased portion a red or pinkish color; spores have been found only in culture. The kernels are brittle and become powdery.

Fusarium III has a sparse white mycelium, found principally at the ends of scattered kernels. It is less destructive than the other two.

(1) Burrill, T. J. and Barrett, J. T. Ear rots of corn. Bull. Ill. Agr. Exp. Sta. 133: 65-109. pl. 11.

The *Diplodia* described by these authors also attacked both kernels and husk. The mycelium is white; pycnidia are formed later on the affected areas.

Subsequently Heald, Wilcox and Pool² described the *Diplodia* attacking corn. It was found on the kernels, bracts and sheaths of corn and inoculation proved its parasitism. The fungus attacking the root and stem was not considered. Selby³ in an addendum in his Brief Handbook of Plant Diseases makes a note concerning a fusarium disease attacking the roots of corn. So far as we know, no subsequent statements or papers relating to this fungus have been published by Selby.

In the fall of 1914 Pammel⁴ briefly described the disease in the Iowa Agriculturist and in the spring of 1915 a press bulletin on this subject was issued by the Iowa Agricultural Experiment station⁵.

The large interest shown in a study of the fusarium diseases of plants indicates the importance of these parasites. Erwin F. Smith⁶, Appel and Wollenweber⁷, Orton⁸, Carpenter⁹, Sherbakoff¹⁰ and others have recently done notable work in the disease as it attacks potatoes. Sherbakoff describes 60 species of *Fusarium* and three of *Ramularia* found on the tubers of the potato. Carpenter described five species on the potato that commonly produce rot and two that invariably do not produce rot. The *Fusaria* are such common fungi of the soil it is not surprising that so many are found on the potato and other plants.

The work of Bolley¹¹ on flax wilt indicates that *Fusarium* is not only a destructive root parasite, but an important factor in the so-called wearing out of soils and one may reasonably con-

- (2) Heald, F. D., Wilcox, E. M., and Pool, Venus W. The life history and parasitism of *Diplodia Zeae* (Schw.) Lev. Neb. Agr. Exp. Sta. Ann. Rept. 22: 1-20 f. 1, pl. 10.
- (3) Selby, A. D. A brief handbook of the diseases of cultivated plants in Ohio. Bull. Ohio Agr. Exp. Sta. 214: 456; Bull. Ohio Agr. Exp. Sta. 249:222; Press Bull. Ohio Agr. Exp. Sta. 348.
- (4) Pammel, L. H. Serious root and stalk diseases of corn. Iowa Agriculturist 15: 156-158. Nov. 1914. f. 1.
- (5) Pammel, L. H., King, C. M., Seal, J. L. Circular, Ia. Agr. Exp. Sta. 21. f. 2.
- (6) Smith, E. F., and Swingle, D. B. The dry rot of potatoes due to *Fusarium oxisporum*. Bull. U. S. Dept. of Agr. Bur. Pl. Ind. 55: 1-64, pl. 1-8.
- (7) Appel, O., and Wollenweber, H. W. Grundlagen einer monographie der Gattung *Fusarium*, Arb. aus d. Kais. Biol. Anstalt Land u. Forstwirtschaft 8: 207, f. 10, pl. 1.
- (8) Orton, W. A. Potato failures in San Joaquin Valley, Calif. U. S. Dept. Agr. Cir. Bur. Pl. Ind. 23: 1-8.
- (9) Sherbakoff, C. D. Fusaria of potatoes. Memoir Cornell Univ. Agr. Exp. Sta. 6: 85-270, f. 1-50, pl. 1-7.
- (10) Carpenter, C. W. Some potato tuber-rots caused by species of *Fusarium*. Jour. Agr. Res. 5: 183-209, pl. A. B. f. 14-19.
- (11) Bolley, H. L. Flax wilt and flax sick soil. Bull. North Dakota Agr. Exp. Sta. 50: 27-57, f. 18. Flax and flax-seed production. Bull. North Dakota Agr. Exp. Sta. 55: 169-198, f. 13. Seed disinfection and crop production methods and types of machinery needed. Bull. N. Dak. Agr. Exp. Sta. 87: 129-166, f. 15, pl. 6.

clude with Selby and Manns¹² that the wheat scab organism, attacking as it does the seedling of wheat, is likewise an important factor in the same direction. W. G. Smith¹³ early recognized that wheat scab is caused by a fungus which he named *Fusarium culmorum*. More details were worked out by C. M. Weed¹⁴.

The continental writers of Europe, however, usually referred to the fungus of wheat scab as *Fusarium roseum*. In the later publications of the Ohio Agricultural Experiment station, Selby¹⁵ and Selby and Manns¹² refer to wheat scab as *Fusarium roseum*. It would also appear from this work of some of the European investigators and of Selby and Manns that the *Fusarium* is connected with *Gibberella saubinetii*. At least it is so regarded by Winter¹⁶ and Saccardo¹⁷. This connection was probably based largely on the association of the *Gibberella* with *Fusarium* just as we have found in the corn disease.

Wollenweber¹⁸ in a paper on the identification of species of *Fusarium* occurring on the sweet potato says that he obtained the *Gibberella saubinetii* (Mont) Sacc. from the *Fusarium roseum* of the authors or the *Fusarium rostratum*. App. and Wollenw. Descriptions of this fungus have usually been based on field material, but Wollenweber makes a careful description of the fungus from cultural material, which shows a wide variation.

The Selby and Manns bulletin does not show conclusively a connection, but points out a strong indication of such relationship. We have not been able to obtain any perithecia from our cultures of *Fusarium* on corn.

There is plenty of evidence that the *Fusarium* of wheat enters the seedling as shown by Selby and Manns, M. S. Mortensen¹⁹, Bolley and others.

Selby and Manns have shown that *Fusarium roseum* attacks the stem of alfalfa. It has frequently been found on red clover in Iowa, and is perhaps a facultative clover parasite. Another fusarium disease occurs on the stems and leaves of carnations and the wilt of the tomato is also said to be due to a similar cause.

While these various plants are said to be attacked by a single species of *Fusarium*, it is not improbable that when the *Fusarium*

- (12) Selby, A., Manns, T. F. Studies in diseases of cereals. Bull. Ohio Agr. Exp. Sta. 203: 185-236. f. 7. pl. 14.
- (13) Smith, W. G. Diseases of field and garden crops, 208.
- (14) Weed, C. M. Soc. Prom. Agr. Sci. 11: 47. f. 1.
- (15) Selby, A. D. Some diseases of wheat and oats. Bull. Ohio Agr. Exp. Sta. 97: 40-43. f. 4.
- (16) Winter, G. Die Pilze. Abt. II. 1: 102.
- (17) Saccardo, Syll. Funga. 2:554.
- (18) Wollenweber, H. W. Studies on the *Fusarium* problem. Phytopathology 3: 24-49. *Rumularia*, *Mycosphaerella*, *Nectria*, *Calonectria*, Phytopathology 3: 197-242. pl. 3. Identification of species of *Fusarium* occurring on the sweet potato, *Ipomoea Batatas*. Jour. Agr. Res. 2: 251-286. pl. 12-17.
- (19) Mortensen, M. S. Tidsskr. Landerb. Planteavl. 18: 177-276.

roseum is worked out as carefully for corn, clover, alfalfa and wheat, it will be found that there are several species, as Appel, Wollenweber, Carpenter and Sherbakoff have shown to be true for the potato. This is also indicated by Burrill and Barrett in their paper on corn ear rots. The work of the authors thus far shows that probably more than one species is found on corn.

A cob rot of corn was studied by E. G. Arzberger²⁰ of Ohio in 1911. This rot was ascribed to *Coniosporium Gecevi* Bubak. This fungus was described as a saprophyte by Bubak²¹ of Bohemia. A similar fungus was sent to Bubak from Bulgaria. Doubt was expressed as to whether the fungus from Bulgaria was parasitic or saprophytic. Bubak considered the Bohemian fungus saprophytic. Arzberger made a large number of inoculations on corn, coming to the conclusion that the *Coniosporium Gecevi* is an obligate saprophyte. He also records the occurrence of *Diplodia* and *Fusarium* in a good many cases on ears of corn in Ohio. The *Coniosporium* has an economic significance as a saprophyte in that it destroys the tissues of the cob. He states that its effect on the kernels is rather limited when compared with the injury of *Diplodia*, *Fusarium* and other fungi.

CHARACTER OF THE FUSARIUM DISEASE ON CORN.

This fusarium disease attacks the roots, the stalks and the ears of corn, at least some seasons. It has not been determined whether all these symptoms are caused by the same organism or not. Burrill and Barrett described four organisms on the ear.

ROOT DISEASE.

During the early part of September, 1914, in many parts of Iowa, corn was lying on the ground. This was not true to the same extent in 1915, tho in quite a number of fields in various parts of the state, corn was down. This condition was attributed to severe windstorms and in some cases to the corn root worm. It was, however, soon found that such corn had frequently been attacked by a fungus, which had killed the roots of the plant. Such roots were always of a reddish color and the plants could be pulled easily from the ground, much in the same way as when the plant is attacked by the corn root worm.

(20) Arzberger, E. G. The cob-rot of corn. Bull. Ohio Agr. Exp. Sta. 265: 67-82.

(21) Bubak. Central f. Bakt. u. Infek, 31: 500-502.

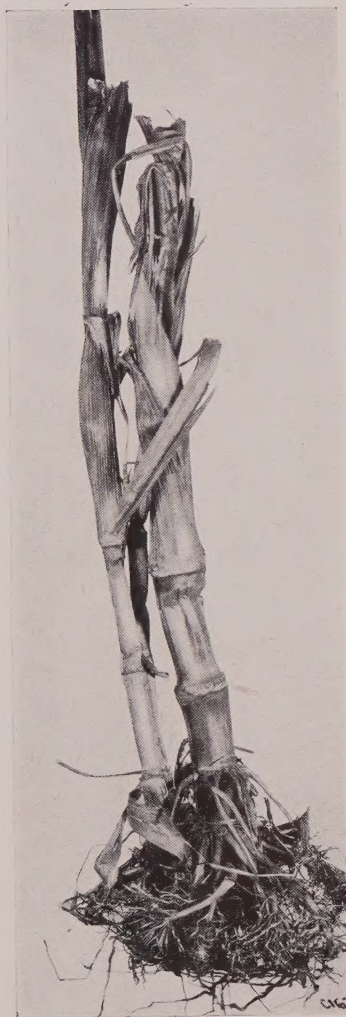


Fig. 2—Healthy corn stalk and roots.
(Photo by Colburn)

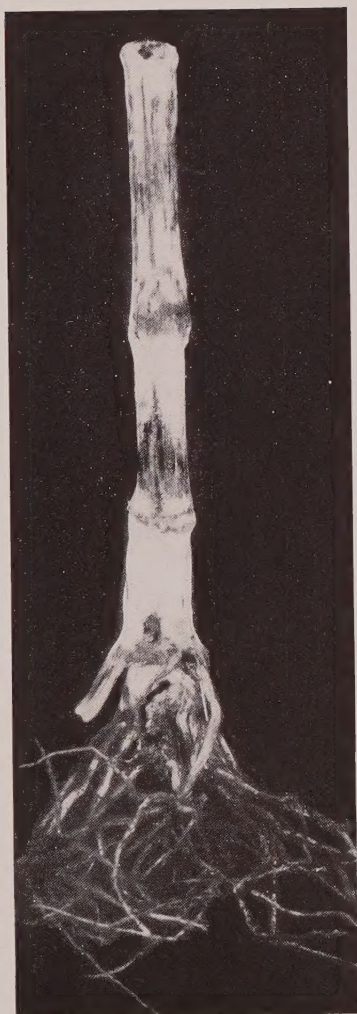


Fig. 3—*Fusarium* growth on corn
stalk. (Photo by Colburn)

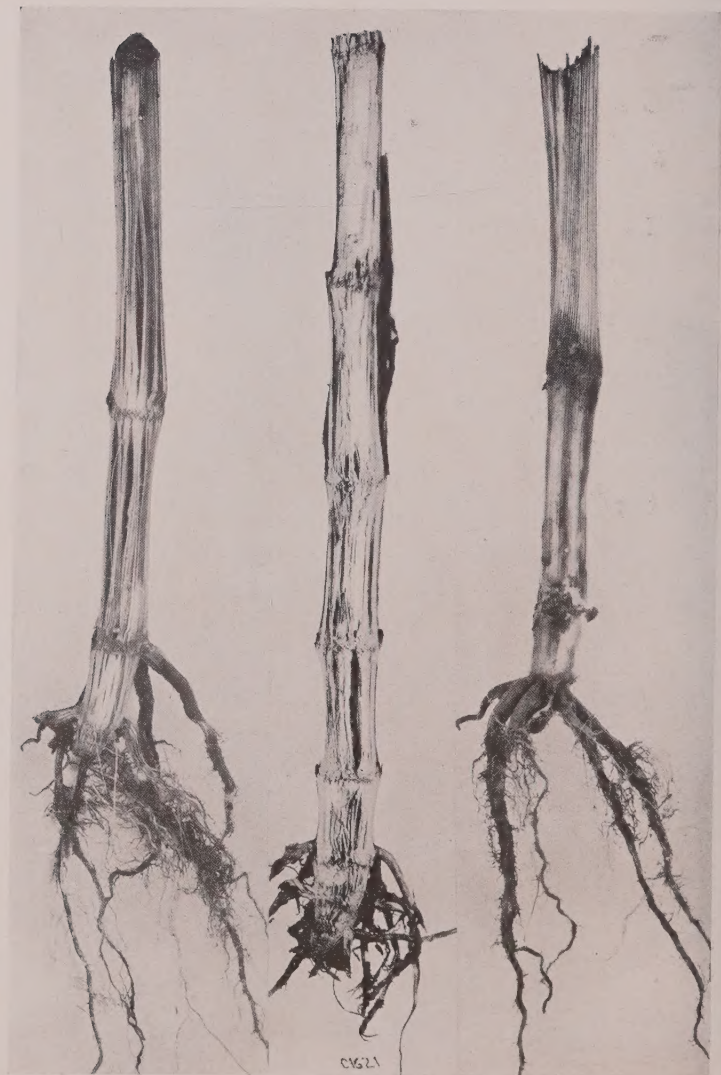


Fig. 4—Diseased stalks of corn, showing fungus growth on exterior and interior of stalk. The roots are also affected. (Photo by Colburn)

THE CORN STALK DISEASE.

In the fields attacked by the disease the injured stalks were broken over at one of the lower nodes or joints or near it. The pith, soft material or parenchyma, in the corn stalk was destroyed, brownish or in some cases reddish in color. The fibers (fibro vascular bundles) were soft and easily broken off. Such stalks were often barren or had only small ears. This was particularly noticeable with the node itself. The small dwarf shoots in the axil of the leaves were frequently decomposed, and brownish in color. On the surface of the stalk and in the nodes there was an abundance of the mold, especially when there was much humidity.

In many cases in 1914, ear rots were plentiful and frequently the stalks were abortive. In 1915 the disease was apparently not nearly as severe as in 1914, tho Mr. Mosher of Dewitt and Mr. G. R. Bliss of Davenport, Ia., report the disease as severe in those sections of the state. The disease was less manifest in 1915, largely because abundant rains favored the development of surface roots of corn.

DAMAGE TO CORN.

It is difficult to estimate the loss due to this disease of corn. In some cases the crop has been damaged 50 per cent; in some cases about 5 per cent, in others 10 to 15 per cent.

The following table gives the results of field studies made in Iowa in the season of 1914:



Fig. 5. Diseased stalk, showing manner of breaking at lower part of stalk. (Photo by Colburn)

OCCURRENCE OF FUSARIUM CORN DISEASE IN VARIOUS FIELDS IN IOWA, 1914.

Locality	Field	Kind	No. stalks Observed	No. stalks Affected	Pct. of Same	No. stalks bearing ears	Signs of disease
Ames	First Bottom	Silver Mine	22	10	46	14	Broken Stalks, Red Roots
Ames	Second Bottom	Silver Mine	25	21	84	16	Red Roots Mold through plant
Ames	Second Bottom	Yellow Dent	28	7	25	23	Broken stalks
Ames	Second Bottom	Silver Mine	26	23	90	16	Broken stalks
Ames	Upland	Reid's Yellow Dent, etc.	250	97	41	150	Broken stalks
Ames	"Hicks"	Mixed var.	25	8	32	19	Broken stalks, fusarium on kernel
Ames	Agronomy Farm	Mixed var.	38	15	39	25	Roots red, nodes broken
Ames	Bottom	Mixed var.	30	15	50	10	Nodes diseased
Moravia	Upland	Reid's Yellow Dent	30	15	43	20	Stalks broken and moldy
Mouth Des Moines River	Alluvial Soil	White Corn	26	6	24	15	Roots & stalks broken
Centerville	Upland	Mixed	35	8	15	20	Roots diseased
Centerville	Side Hill Upland	Mixed var.	35	8	15	20	Roots diseased

The percentage of injury, due to *Fusarium* of corn in central Iowa in 1915 is given below:

INJURY DUE TO FUSARIUM OF CORN, FALL OF 1915.

Field No. 1. Ames.			
No. stalks in row	No. healthy stalks	No. diseased stalks	Percent of plants with disease
89	69	20	22.4
104	90	14	13.4
62	49	13	20.9
92	79	13	14.1
74	66	8	10.8
82	68	14	17.0
Field 2. Ames.			
152	106	47	30.7
165	121	44	26.8
75	50	25	33.3
133	90	43	33.0
160	112	48	30.0
154	112	42	27.2
Field 3. Ames.			
200	150	50	25.0
240	191	49	20.4
140	112	28	20.0
361	308	53	14.4
189	145	44	23.2
231	188	43	19.0
Field 4. Ames.			
94	77	17	18.0
89	74	15	16.8
120	108	12	10.0
114	99	15	15.1

EAR ROTS.

Nearly every farmer has observed an occasional ear attacked by a mold. The molds are of three kinds. One attacks the kernels, husks, cobs and sheaths, the threads of the mold occurring thru the cobs and sheaths, and destroying the kernels completely. This fungus occasionally produces a pinkish color. The second kind of mold produces a deep pink or red color. The threads of this fungus are felty and penetrate the husks; the kernel becomes brittle and red. The third type of mold attacks an occasional kernel and is not so serious. Its threads are white.



Fig. 6—Ears of corn affected by *Fusarium*. (Photo by Gardner)



Fig. 7—*Fusarium* on kernels of corn. (Photo by Colburn)



Fig. 8- *Fusarium* on kernels of corn. (Photo by Colburn)

In 1914 here was much complaint in Iowa about ear rots and 1915 reports indicate an even greater amount of it, due to *Fusarium* and other molds.

A fourth fungus, parasitic in character, was found on the ears, stems and sheaths, and also on the roots. It is known as *Diplodia Rot*. It is not, however, the cause of the falling of corn.

THE FUNGUS.

The fungus disease under investigation will be definitely referred to as *Fusarium*. The mycelium is whitish, felted, branched and septate. In the interior of the plant attacked its threads are colorless. The mycelium penetrates not only the living cells, but also occurs in the intercellular spaces. It occurs abundantly in the embryo and endosperm of the seed. The mycelium on the host produces both macroconidia and microconidia. The macroconidia are curved, 5 to 7 celled and colorless. They may be obtained in large numbers from the surface of the sheath and corn stalk, especially in the vicinity of the node. The microconidia are sub-spherical to elliptical and one-celled, borne on the ends of the hyphae. The fungus causes the cells of the host to become reddish in color, and according to our view is a facultative parasite, its destructive character varying with the season.

The perithecia of *Gibberella* occurs abundantly on the sheath and stem of corn plants. These perithecia are violet black, many celled, arising from a dark colored mycelium. The perithecia contain many asci with numerous three celled colorless ascospores. Thus far we have been unable to show that this fungus is connected with the *Fusarium*.

CULTURAL CHARACTERS.

The fungus can easily be cultivated on agar, potato, rice agar, cabbage, pumpkin and corn. The fungus is easily plated by using agar, then transferred to potato and other media. On rice agar, it forms a white colony with a fluffy growth that soon colors the upper part of the medium pinkish. The color does not, however, penetrate the medium very far. In cabbage agar the color is deeper and diffuses more. Macroconidia in such cultures measure 10 to 35 μ by 3 to 4 μ . Microconidia measure 2.5 to 5 μ by 2 to 3 μ .

In cultures chlamydospores are produced at the ends of short lateral branches of the hyphae; they are elliptical to spherical in shape, smooth and brownish in color; they vary in size from 10 μ to 25 μ in diameter.

Smaller colorless spores are produced in the hyphae, varying

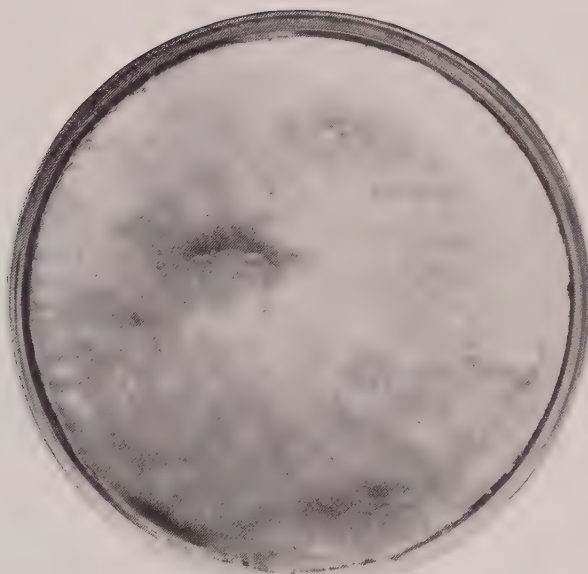


Fig. 9 *Fusarium* on corn meal. (Photo by Gardner)



Fig. 10—Culture of corn *Fusarium* on medium of alfalfa root decoction and agar. (Photo by Colburn)

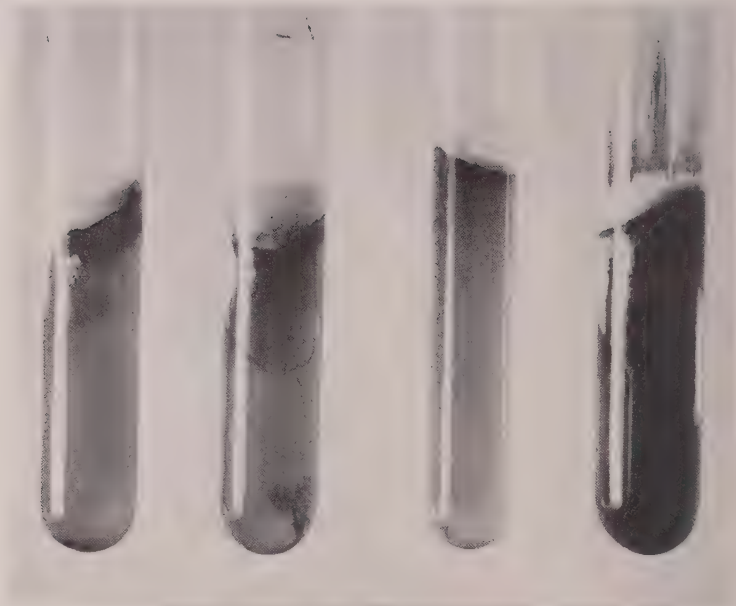


Fig. 11—*Sorghum Fusarium* on rice agar, in first three tubes; corn fusarium on pumpkin agar, in fourth tube. (Photos by Colburn)

in size from $10\ \mu$ to $20\ \mu$; these chlamydospore-like structures should not be mistaken for the short cells that occur in the hyphae which produce the spores. Thus far we have been unable to obtain a perithecial form of the fungus.

On pumpkin agar the fungus made a very rapid growth. The mycelium was white and flocculent, but gradually changed in color; the surface of substratum is white, blending into brown, to yellow and then pink. Both macroconidia and microconidia are produced.

On radiclecola agar the growth made is very scant. The mycelium remains pure white, and is non-pigmented. The medium is given a very distinct purple color. A great number of macroconidia and microconidia are produced.

INOCULATIONS.

Young plants of corn were inoculated May 21 with the fungus by making a dilution of spores in water and spraying the stalks of corn at the joints with an atomizer. The solution ran down between the sheaths and stalk to the node, where the infection was

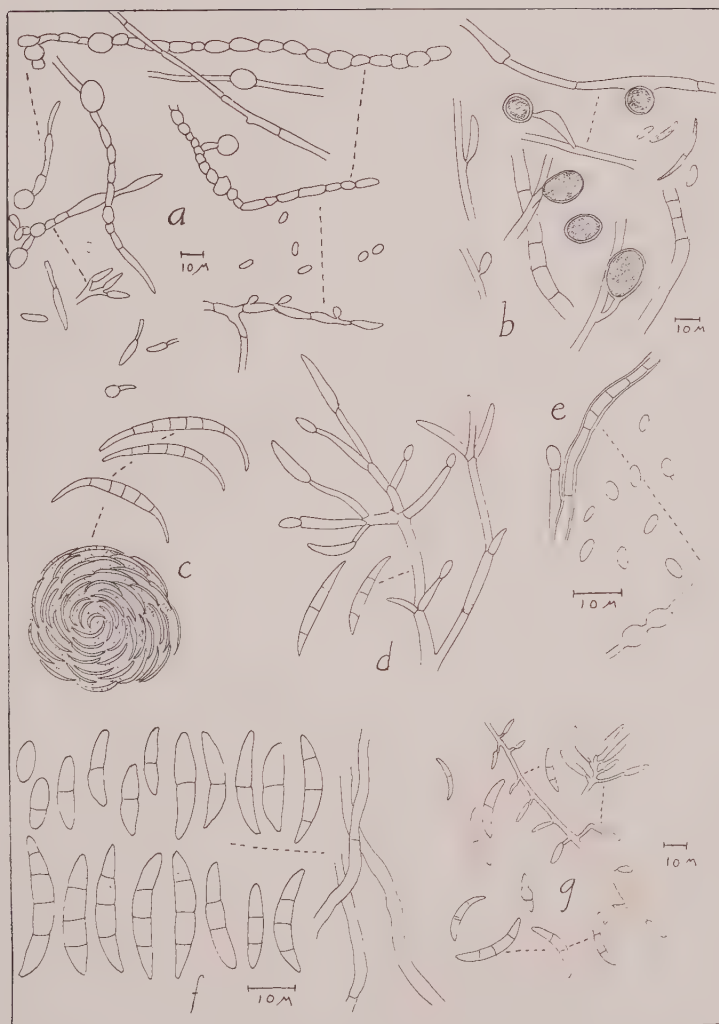


Fig. 12—Spore forms from *Fusarium* on corn. (Drawn by C. M. King)

- Hyphae and chlamydospore-like swellings, from old agar culture.
- Chlamydospores, from agar culture.
- Sporodochium of macroconidia, surface of corn stalk.
- Conidiophore and macroconidia, from fungus tufts on stalk.
- Hyphae and microconidia, from agar culture.
- Macroconidia and hyphae, from potato culture. 1-12 oil immersion.
- Macroconidia and hyphae, from agar culture.

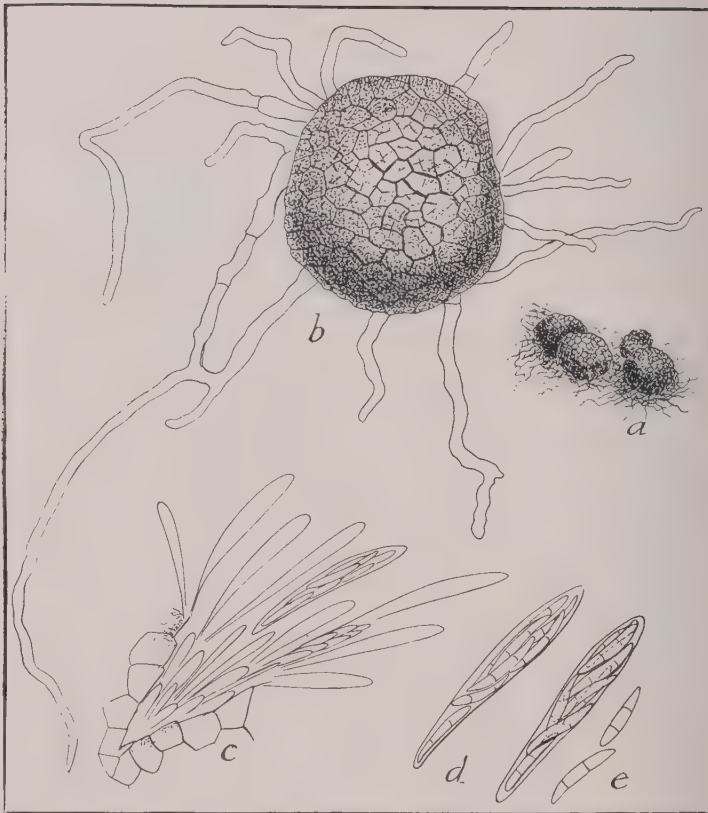


Fig. 13—Perithecia forms from *Gibberella*.

(Drawn by C. M. King.)

- a. Perithecia of *Gibberella* from stalk of corn.
- b. Same enlarged.
- c. Expulsion of asci from perithecia.
- d. Asci.
- e. Spores.

first noticed July 21. Here a mass of mycelium formed at the node, which seemed to cause the stalk to decay slowly. The material between the vascular bundles is destroyed and the stalk becomes so weak, at this point, that a slight wind causes it to break. Within the stalk the fungus produced a pink coloration. The roots possessed the same pink coloration and showed signs of decay.

The inoculation experiments indicate that the fungus enters not only with the seed, e. g. by seminal infection, but that the

undeveloped shoots in the axils of the leaves probably are responsible for some of the infection in the field.

HOW THE DISEASE SPREADS.

This disease probably spreads largely with the seed corn. The fact that it occurs in the embryo accounts for the wide distribution even on new soil. F. L. Mosher, formerly county agent in Clinton county, records a case where a farmer in the vicinity of Miles, Iowa, secured seed from central Iowa. The crop from the seed was badly diseased, while other corn right beside it was normal. The experience of H. D. Hughes, of the Iowa Agricultural Experiment station, with sorghum from Kansas also indicates that the sorghum disease is spread with sorghum seed.

TREATMENT.

Because the study of the disease has not gone far enough, we can, at this time, make few suggestions in regard to treatment except the rotation of crops and treatment of seed to kill the spores on the surface. Affected seed germinates poorly. When the mycelium occurs in the embryo nothing can be done. Careful seed selection is a good measure of precaution; in no event use seed corn that comes from a diseased field. The most feasible line of preventive work will be the development of resistant varieties.

FUSARIUM ON SORGHUM.

During the fall of 1914 we received from H. Willis Smith of Garden City, Kansas, some sorghum canes whose roots were reddish and with a copious mass of spores on the cane surface and an abundance of mycelium. Mr. Smith, who had seen the published note of the Iowa station on this disease, wrote that he was familiar with a disease of sorghum that was similar to the one described on corn. An examination of the Garden City material indicated that the *Fusarium* on sorghum was similar to the one on corn.

The matter had no further consideration until H. D. Hughes, chief of the farm crops section of the Iowa Agricultural Experiment station, in October, 1915, called our attention to a sorghum disease on the college farm. He stated that the seed came from H. Willis Smith of Garden City, Kansas, with whom we had correspondence last year in regard to the disease. Mr. Hughes wrote Mr. Smith and received the following interesting letter:

Dear Sir:

Your letter of recent date came to hand in due time. I will say in reply that your experience with my sorghums may prove as valuable to me as though the crop had been healthy. You say one variety seemed to fail to develop the disease. This is very interesting to me as I had not been able to determine which of

several were most resistant to the trouble. I wish you would look up your records and tell me which kind failed to succumb to the disease.

All of the varieties I sent to you have been grown side by side in breeding rows for several seasons. The heads have been bagged and inbred to prevent crosses being formed. In 1913 the Jerugo was seriously affected, while the Prog. Kafir in an adjacent row and planted at the same date showed but a very slight affection. In 1914 in a plot where there was just one row each of 15 kinds the Dwarf B. H. White Kafir was so seriously affected that 30% of the plants failed to make heads and not more than 10% made fairly good heads. None of the other kinds were at all seriously affected so far as could be determined by the naked eye. These heads were all bagged before they bloomed and the seed I sent you was selected from this plot. I planted seed of these kinds again this year in breeding rows, allowing only 25 feet in the row to each selection. I planted from 3 to 10 selections of each strain. The disease showed itself in a serious form on the B. H. White Dwarf Kafir again, even tho I selected apparently healthy heads for seed. This strain of this Kafir seems to be permanently ruined. I selected good heads from the Jerugo in 1913; in 1914 these were planted. They produced a variable bunch of stuff, large and small, early and late, but only one or two plants showed visible signs of the disease. Heads were selected from this plot and planted in head rows over a square $\frac{1}{4}$ acre plot; not a sign of the disease was visible in this plot, 1915. The plants were uniform in size and vigor and each selection was *very* uniform in itself. I will send you some seeds from this plot. I should like you to examine it and report if the fungus is present.

The disease takes a different form here than you report. The plants which fail to make seed are spoiled by decay setting in at the first joint, then the plant stools, and often the suckers develop the disease by the crown joint or node. When the stalk is not killed at this early stage it usually makes at least a feeble growth and a small head.

Plants grown from infected stock are apt to be slow of growth and late about maturing.

This disease is all over western Kansas, and has been for twenty years, in some localities. As it is not visible on only the most seriously affected plants, it has been generally overlooked. The Kafir heads rotted at the Hayes, Kansas, station this year.

We had the same trouble here in 1913 and that was a dry, hot season. Hoping you can tell me which of my varieties proved resistant with you this year,

Yours truly,

H. WILLIS SMITH.

CHARACTER OF THE SORGHUM DISEASE.

When the *Fusarium* attacks sorghum, the canes break at the joints, sometimes beginning at the first joint; more frequently most of the joints are attacked. These readily break off. The roots are apparently not so seriously affected as in corn, as the plants are removed with difficulty from the ground. This bears

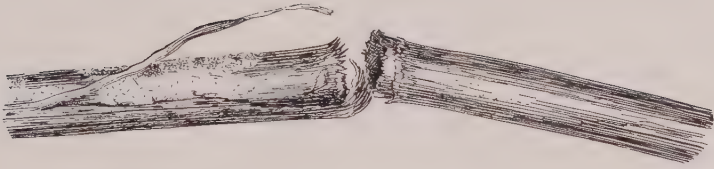


Fig. 14—Diseased sorghum stalk, showing how it is attacked and manner of breaking.
(Drawn by C. M. King.)

out the observations of Mr. Smith that such plants stool and that often the suckers develop the disease at the crown point. We found in many cases that the plants affected are enfeebled by the disease and that the heads are small and not fully filled.

The diseased heads show the fungus in the seed. Where the fungus occurs at the nodes the spores are found in great abundance on the surface of the stalk. The mass is whitish with a slight purplish tinge. The interior of the cane is disintegrated and purplish or brownish in color, with an abundance of the mycelium. The leaf sheaths give sufficient protection from drying out so that spores are produced there in great numbers. There is little decay beyond the nodes, most of the injury being confined to within about half an inch of the node. The destruction of the parenchyma cells is similar to that of corn, leaving the fibers of the plant. The point of special interest in connection with the disease at Ames is that it was brought in the seed from Kansas.

The following notes were made on the experimental plots:

Row	No. stalks	Healthy	Diseased	Pct. of diseased plants	Variety
1					
2	803	164	639	78	
3					
4	841	185	656	78	Buff Kafir
5					
6	789	204	585	74	Early Jerugo
7					
8	821	66	755	92	Mammoth Hopper Proof

Row	No. stalks	Healthy	Diseased	Pct. of diseased plants	Variety
9					
10	794	15	779	97	Mammoth Davola
11					
12	809	45	764	94	Dwarf Mammoth Davola
13					
14	789	98	700	87	White-hulled Triola
15	392	205	187	47	California Golden
16					
17	782	409	373	47	Koliang

From observations made in Muscatine county, M. E. Olson reports a fair average of sorghum stalks affected by disease in that locality to be 73 per cent.

There were sorghum and broom corn in other experimental plots at the Iowa station, but in these we did not find the disease, except that the broom corn in the vicinity of the sorghum grown from Kansas seed had a few diseased plants.

CHARACTER OF THE FUNGUS.

The septate branched mycelium of the fungus which attacked the sorghum is whitish and flocculent; the macroconidia are 4 to 6 septate, colorless, sickle shaped, 35 to 50 μ long and 5 to 6.25 μ in width; the microconidia are colorless, 1.75 to 8 μ in length and .6 to 1.75 μ in width. Chlamydospores are borne on lateral branches and vary in length from 15 to 25 μ and in width from 14 to 20 μ .

CULTURES OF FUSARIUM UPON SORGHUM.

Plain Agar. The fungus makes a medium growth and is white and flocculent. Both the fungus and medium retain their original color. Microconidia are produced in 26 hours in abundance, while the macroconidia make their appearance about 12 hours later.

Potato Agar. Small growth is made and the mycelium adheres closely to the surface of the medium and changes but slight-



Fig. 15—Spore forms from *Fusarium* on sorghum cane.
 a. Macroconidia, from drop culture 1-12 oil immersion.
 b. Microconidia (some germinating), from drop culture.
 c. Macroconidia germinating.
 d. Germinating macroconidia and microconidia, from drop culture.
 e. Chlamydospores, from agar culture.
 f. Hyphae.
 g. Hyphae producing microconidia.
 h. Hyphae producing microconidia.
 i. Germinating microconidium spore.
 j. Macroconidia.
 k. Conidiophore and macroconidia.
 l. Spores from fungus masses on cane.

ly in color. Macroconidia and microconidia are produced in large numbers.

Potato Plug. The fungus makes a rapid growth; the fungus is slightly colored pink, after a very short growing period. Both microconidia and macroconidia are produced.

Rice Agar. The fungus makes a rapid growth of white, flocculent mycelium, which produced microconidia and macroconidia. The mycelium remains white, but the medium is gradually turned pink after 10 days.

Pumpkin Agar. On this agar the fungus begins by making a rather slow start, but does make later a relatively large growth. The medium is changed slightly in color. An abundance of microconidia and macroconidia is produced.

Radicicola Agar. Only a scant growth is made and the mycelium is white and adheres closely to the medium, microconidia and macroconidia are both produced.

